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REMOTE SENSING ASSESSMENT OF FIRE AND BURN SEVERITY IN THE ALASKA BOREAL FOREST REGION

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INTRODUCTION

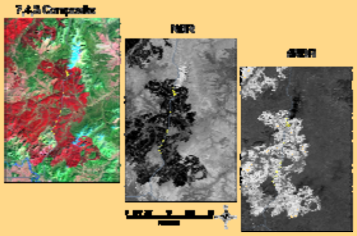
Over the past 4 decades, there has been a doubling of the annual area burned across the North American boreal region resulting in new challenges for fire management and intensified concerns about the effect that an increase in large wildfires may have on ecosystems and atmospheric carbon. The severity of a fire can be of great importance to the post fire environment, ecological recovery, and in quantifying carbon that is emitted to the atmosphere, in the form of carbon dioxide (CO_2) carbon monoxide (CO), and other greenhouse gasses. In this poster we review results of several studies highlighting the utility and issues of using remote sensing and field measures used to connect to remote sensing to assess fire and burn severity in Alaskan boreal forests. This poster reviews several studies to be presented in a special issue of *International Journal of Wildland Fire* on Landsat remote sensing of fire severity in the boreal region of North America. The results presented endorse a need for additional studies to assess the dNBR index under a variety of ecological and fire conditions.

Background

Normalized Burn Ratio (NBR) & differenced NBR

NBR = (NIR – SWIR) / (NIR + SWIR)

dNBR = NBR pre-fire – NBR postfire



Above: Typical dNBR map from the 2004 Porcupine Fire near Tok, AK. A dNBR is derived from pre- and post-fire NBR maps from Landsat TM or ETM+ images.

Composite Burn Index (CBI)

Ocular-based field method of assessing severity developed to be used with dNBR by Key and Benson 2006 (see CBI form above center)

Right: Deep organic material (duff) is found in many boreal ecosystems due to slow decomposition rates. These are variably vulnerable to fire, which is an important component of fire severity in Alaskan fires.

Field-measured Severity

Example CBI form

CBI poorly correlates to specific severity measures for boreal ecosystems

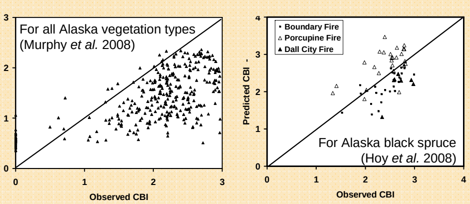
Surface Measurement	Ecological or Environmental Effect
Canopy tree mortality	Stand age structure Seed availability
Canopy biomass consumption	Trace gas emissions Carbon and nutrient cycling Seed availability
Fraction of trees standing	Seed dispersal distance
Depth of burning of the surface organic layer	Trace gas emissions Carbon and nutrient cycling Availability of propogules in surface organic layer (affects level of vegetative reproduction)
Depth of the remaining surface organic layer	Substrate quality – bulk density, hydraulic conductance (affects substrate quality for seedling germination and soil water repellency) Soil temperature

	Independent Variables								
	CBI total			CBI canopy			CBI substrate		
Dependent variables	Adjusted R^2	F	p	Adjusted R^2	F	P	Adjusted R^2	F	p
Canopy damage rating	0.37	47.0	<0.0001	0.36	46.8	<0.0001			
% standing trees	0.10	9.94	0.0023	0.00	0.49	0.48	0.35	44.4	<0.0001
Organic layer depth	0.26	29.0	<0.0001				0.35	44.1	<0.0001
Absolute depth reduction	0.00	0.59	0.45				0.06	6.41	0.014
Relative depth reduction	0.22	22.9	<0.0001				0.39	53.9	<0.0001
Substrate exposure index	0.22	23.5	<0.0001				0.47	68.6	<0.0001

Above bottom: Linear regression model outputs for fire severity characteristics (***above top, right***) as a function of the CBI (***above top left***) from Kasischke *et al.* 2008. Results show specific surface measurements of severity do not correlate to either total or component CBI scores.

CBI vs. dNBR

To evaluate the ability of dNBR to map variations in CBI across Alaska, we used the equation developed by Sorbel and Allen (2005) - which provided a good relationship between CBI and dNBR in their study - to estimate CBI from dNBR at several 2002 Alaska wildfire sites (***below***). The Sorbel and Allen (2005) equation significantly underestimated CBI for the plots used in the Murphy *et al.* (2008) study that were established across many vegetation types. For plots in black spruce stands (Hoy *et al.* 2008) the predicted CBI values followed the expected trend with points scattered around the 1:1 line, but with scatter.



Comparison between CBI values predicted using dNBR with the equations of Sorbel and Allen (2005). *(Figure 2 in French et al. 2008)*

Remote Sensing of Severity

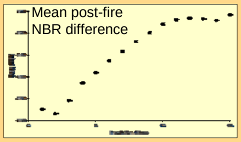
Northern latitudes present issues for remote sensing not applicable at lower latitudes, especially for methods that require anniversary images:

Shallow sun elevation angle: Max < 50° in Alaskan boreal region; this produces complications as sun angle changes through the summer (see below).

Rapid & variable seasonal plant phenology: Plants green-up differently from year to year due to precip/temp variations; plant senescence can start in early Aug.

Limited Landsat archive in Alaska: Poor collection in 1980's; loss of on-board recorders on L5 in early 1990's required direct download; no permanent download station in Alaska at the time.

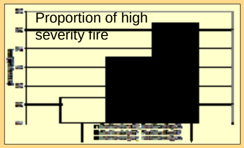
Trend in NBR due to sun elevation & topography



Above: NBR post-fire difference (4 Aug - 6 Sept) by insolation class. The only major topographic factor that changed in the two post-fire images was sun elevation (40 versus 30 degrees). If NBR was independent of topography, the result would approximate a random normal distribution centered at zero.

False trends in dNBR

Below: Artificial increase in "high severity" pixels within the 2004 Boundary Burn due to change in image acquisition dates. The mean dNBR for the burned pixels was significantly different depending on the pre-fire or postfire image used.



Figures from Verbyla *et al.* 2008

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